Radio weather transmissions in the Antarctic

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Received September 1990

ABSTRACT. During seven summer Brazilian expeditions to the Antarctic Peninsula area the author used radio weather transmissions to collect data for synoptic analysis and operational weather forecasting. A particularly intensive effort aboard *Barão de Teffé* in 1989–90 yielded detailed information on frequencies, schedules, procedures and contents, which should be useful to radio-operators, meteorologists, and other Antarctic workers since official publications listing Antarctic radio transmissions are out-dated or incomplete. Radiotelegraph broadcasts particularly valuable to mariners, which may replace or complement facsimile transmissions, are made by Valparaiso, Punta Arenas, and Buenos Aires. Because of unreliable reception of regular fax and teletype broadcasts, synoptic reports were copied directly by monitoring voice and Morse point-to-point circuits, gaining time crucial to operational decisions. Especially useful sources of reports were the Frei, Marambio, and Faraday collections, and the USSR radiotelegraph communications carrying land and ship reports for all sectors of Antarctica and southern hemisphere oceans. Other signals, eg from Chilean lighthouses, ships of opportunity, and aircraft have become useful sources of meteorological information, especially for Drake Passage since Chile has suspended broadcasts, adversely affecting weather forecasting in the area. An insight into weather conditions on the Antarctic Plateau, as well as a sense of history in the making, were gained by monitoring Adventure Network International's radio frequencies.

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Introduction: radio monitoring

Weather so notoriously affects human activities in the Antarctic that the expedition meteorologist is constantly pressed to give professional advice to his different customers, be they ship skippers, helicopter pilots, chief scientists, or simply someone who gets sea-sick and needs to take his preventive medicine two hours before the ship begins to roll and pitch. To provide adequate services the meteorologist is particularly dependent upon timely data provided by different telecommunications means, such as high frequency (HF) radio and satellite links.

In my seven summer trips to the Antarctic Pensinsula area as a meteorologist with the Brazilian Antarctic Programme (Simoes 1984), beginning in 1982–83 aboard R/V *Prof. W. Besnard* of the University of São Paulo, and lately (1988–89 and 1989–90 seasons) on the naval oceanographic support ship *Barão de Teffé*, radioteletype (RTTY) and facsimile (fax) equipment were thought of as primary means of automatically receiving meteorological data; no satellite receiving equipment was available, except for irregular periods at Comandante Ferraz station. Yet, to satisfy heavy operational demands bearing on the safety and efficiency of navigation, helicopter flights, shore parties, research activities etc. I found it necessary to make additional efforts to collect weather data by radio, not only by having RTTY, fax and CW (Morse code) broadcasts copied, but also by monitoring point-to-point communications directly.

For example, helicopter flight briefings on *Teffé* were held two hours before take-off and fresh weather reports needed to update forecasts would often not be available. However, by monitoring point-to-point circuits it was possible to receive the Antarctic synoptic reports fully one and a half to half an hour before a broadcast started. In this way, for example, a 0900 UTC surface chart could be made ready at 0855. Besides, poor propagation conditions and equipment shortcomings fairly often rendered reception of the official RTTY and fax schedules impossible. Also, fax charts and forecasts are put out by main meteorological offices in the area twice a day, whereas weather situations in the Antarctic can change significantly in three hours or less.

This article presents a compilation of time schedules, frequencies, contents and other information on Antarctic meteorological radio transmissions as I actually heard them, mostly aboard *Barão de Teffé* during the 1989–90 season. Such information will be of use to radio-operators, meteorologists, and planning and logistic officers engaged in Antarctic work. Also I give an account of communications pertaining to new developments in Antarctica, for example the activities of private groups operating in the continent's interior.

Antarctic communications

The current Antarctic meteorological radiocommunications system originated from a 'mother-daughter' network system established during the International Geophysical Year (IGY), linking stations operated by different nations

Table 1. Weather stations used for analysis and forecasting in the South American Antarctic sector in the 1989–90 season. (See Fig. 1).

Station	WMO No.	Callsign	Latitude	Longitude	Altitude (m)	Remarks
1. Southern Chile						
Cabo Raper	85889	CBM2	46°50'S	75°35'W	40	
San Pedro	85895	CBS	47°43'S	74°55'W	22	
Puerto Natales	85921	CBM22	51°40'S	72°31'W	-	
Punta Delgada	-	CBM5	52°27'S	69°53'W	-	lighthouse
Evangelistas	85930	CBM73	52°24'S	75°06'W	52	
Dungeness	85931	CBM71	52°23'S	68°26'W	-	lighthouse
Fairway	-	CBM4	-	-	-	lighthouse
Espiritu Santo	-	CBM72	52°40'S	68°37'W	-	lighthouse
Bahia Felix	-	CBX	52°58'S	74°04'W	15	lighthouse
Punto Arenas	85934	-	53°02'S	70°51'W	31	
Magellanes (Navy)	85935	CCM	53°09'S	70°54'W	8	
Isla Dawson	85937	-	53°48'S	70°24'W	-	
Isla Nueva	85969	-	55°12'S	66°30'W	-	
Cabo de Hornos	85970	CBN	55°37'S	67°18'W	50	
Diego Ramirez	85972	-	56°32'S	68°43'W	-	
Puerto Williams	85967	-	54°06'S	67°37'W	8	
2. Southern Argentina						
Santa Cruz	87912	-	50°01'S	68°34'W	111	
Rio Gallegos	87925	-	51°37'S	69°17'W	19	
Cabo Virgenes	87928	-	52°20'S	68°21'W	24	lighthouse
Rio Grande	87934	-	53°48'S	67°45'W	11	
Ushuaia	87938	-	54°48'S	68°19'W	14	
3. Antarctica						
a) Chilean						
Frai	89056	CAN6D	62°15'S	58°55'W	10	
Arturo Prat	89057	-	62°30'S	59°41'W	5	
O'Higgins	89059	-	63°19'S	57°54'W	10	
b) Argentine						
Orcadas	88968	LOK	60°45'S	44°43'W	6	
Jubany	89053	-	62°14'S	58°38'W	4	
Esperanza	88963	LTS4	63°24'S	56°59'W	13	
Marambio	89055	LUU	64°14'S	56°43'W	198	
San Martin	89066	LTS2	68°08'S	67°08'W	4	
Belgrano II	89034	LTA8	77°52'S	34°37'W	-	
Matienzo	88970	-	64°59'S	60°05'W	32	
Almirante Brown	88971	-	64°52'S	62°52'W	7	
c) United Kingdom						
Signy	89042	ZHF43	60°43'S	45°36'W	12	
Faraday	89063	ZHF44	65°15'S	64°16'W	9	
Rothera	89062	ZHF45	67°34'S	68°08'W	17	
Fossil Bluff	89055	-	71°20'S	68°21'W	55	
Halley	89022	VSD	75°30'S	26°39'W	32	
d) USSR						
Bellingshausen	89050	UGE2	62°12'S	58°56'W	16	
Druzhnaya 1	89044	RULE	77°34'S	40°13'W	35	
Druzhnaya 2	-	ULO77	74°30'S	62°00'W	-	
Novolazarevskaya	89512	UDY	70°46'S	11°50'E	-	
Molodezhnaya	89542	RUZU	67°40'S	45°51'E	40	
Mirnyy	89592	UUT	66°33'S	93°01'E	30	
Russkaya	89132	UDR3	74°46'S	136°51'E	-	
Leningradskaya	89567	UMA4	69°30'S	159°23'E	300	
Vostok	89606	RKIS	78°27'S	106°52'E	3420	
e) Others						
Arktowski	98052	3ZL301	62°10'S	58°28'W	2	Poland
Palmer	89061	NGH	64°46'S	64°05'W	8	USA
Siple	89083	-	75°55'S	84°15'W	914	USA
Artigas	89054	-	62°10'S	58°50'W	10	Uruguay
Great Wall	89058	-	62°13'S	58°58'W	10	China
Georg v. Neumayer	89002	DB9020	70°37'S	08°22'W	40	Germany
SANAE	89001	ZRP	70°19'S	02°21'W	52	South Africa
Syowa	89532	-	69°00'S	39°36'E	21	Japan
King Sejong	89251	-	62°13'S	58°45'W	-	Korea
Patriot Hills	-	-	80°20'S	81°15'W	872	ANI Inc.

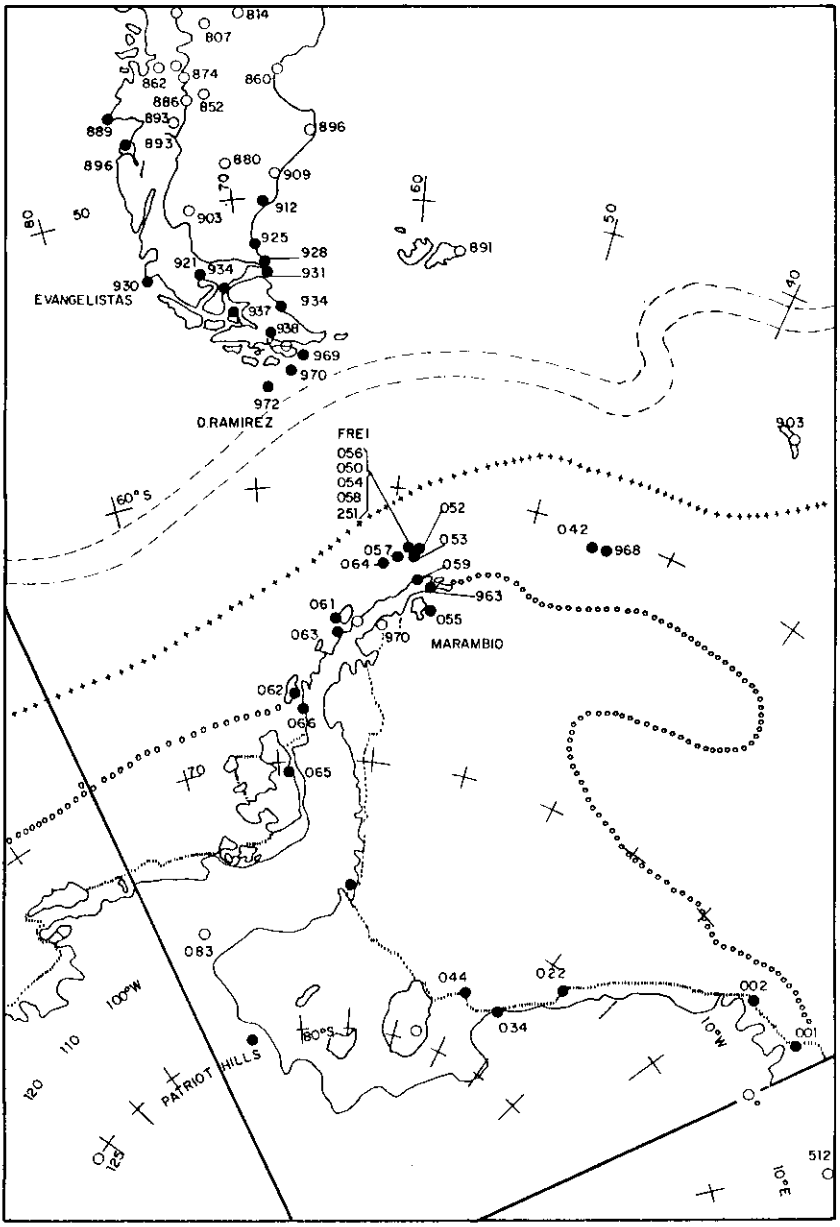

Fig. 1. Location map: stations are identified by the last three digits of their station number (Table 1). = = = Antarctic convergence: + + + winter pack ice limit: o o o summer pack ice limit.

(Sheffield 1957; Walton 1987). It allows for interchange of reports and their dissemination by collecting centres every three hours. Meteorological transmissions at stated wavelengths and time schedules, and in different modes such as facsimile and teletype, are listed in the SCAR Telecommunications Guidance Manual (SCARCOM 1985), of which a new edition was announced late in 1988. This manual and other official publications containing information on world radio meteorological broadcasts (WMO 1986; Admiralty 1987; NOAA 1985; Armada Argentina 1988) are of course very useful to Antarctic workers, but are sometimes considerably out-of-date or incomplete. For example the Argentine Navy publication just mentioned (7th edition, 1988) still lists Buenos Aires' LRO/LRB RTTY broadcast which ceased in 1985.

Most weather messages are sent in numerical codes of the World Meteorological Organization (WMO). Thorough familiarity with such code forms as SYNOP, SHIP, IAC and TEMP is needed to read the messages and use their information for operational purposes. Techniques for plotting and analyzing weather charts by mariners are explained in a WMO publication (WMO 1983).

Table 1 lists meteorological stations used on board *Teffé* for weather forecasting in the South American sector of the Antarctic, compiled from several sources (WMO 1986, SCARCOM 1985, Armada Argentina 1988), corrected and updated through information obtained personally during visits made to forecasting and radio centres in Punta Arenas and Frei. These are mapped in Figure 1.

All information in this report, unless otherwise noted, was collected between 5 December 1989 and 22 February 1990. Receiving equipment included a Microlab communications receiver located in the ship's navigation room and a Sony 2001 receiver connected to a makeshift aerial, located in the author's cabin. Reception was plagued by all kinds of radio noise generated locally, and especially by the ship's own transmitters. All times are UTC unless otherwise stated.

Broadcasts for shipping and aviation

For mariners cruising the southern oceans and bound for Antarctic waters, CW broadcasts of weather bulletins for shipping are very useful sources of forecasts and other meteorological information such as summaries of synoptic situations and coded chart analysis. They may supplement or replace facsimile transmissions when these cannot be copied.

We did not include RTTY and fax broadcasts by Molodezhnaya (RUZU), only irregularly copied on 15830 kHz. Information on the Northwood's South Atlantic fax broadcasts, made on 16115 and 8334 kHz, can be obtained from the Admiralty List of Radio Signals (Admiralty 1987). ZKLF Wellington was occasionally heard in CW on 13350 kHz between 0900 and 0930, sending storm warnings, synoptic summaries and forecasts for the South Pacific as far eastwards as 120°W and southward to 55°S. Adding information from ZKLF, CBV and CBM, complete coverage of a huge area of the South Pacific Ocean can be obtained through CW broadcasts. Both CBV and

CBM extend their coded analysis well into the Antarctic as far as 70° or 80°S. ZLZ/ZLX Wellington has been heard in past seasons on 14850 in CW, sending synoptic reports and weather summaries.

Frei and the Frei-Marambio link

The Frei radioteletype broadcast, the main centralized source of synoptic data for the Antarctic Peninsula area, is made at 50-baud speed every 3 hours at half hour past the synoptic hours, beginning at 0030, and lasting for about 30 minutes. There are eight main blocks of data:

1) surface reports (SYNOP) for Chilean stations Frei, Prat, and O'Higgins, plus Artigas (Uruguay), Great Wall (China) and occasionally King Sejong (South Korea);
2) surface reports for Argentine stations Marambio, Jubany, Esperanza, Orcadas, San Martin and Belgrano, plus Juan Carlos I (Spain) and Arctowski (Poland);
3) surface reports for all Soviet stations (Molodezhnaya, Novolazarevskaya, Mirny, Vostok, Leningradskaya, Russkaya, Druzhnaya, Bellingshausen), plus Arctowski — often delayed three or six hours;
4) surface reports for UK stations Faraday, Halley, Signy, Rothera and Fossil Bluff, plus Palmer (USA) and ship reports from *John Biscoe* and *Bransfield*, often delayed three to six hours or absent;
5) Soviet ships (all sectors of Antarctic and sub-Antarctic oceans), for 0000, 1200 and 1800, delayed three to 12 hours;
6) upper air 0000 soundings (TEMP) for Soviet stations Bellingshausen, Vostok, Molodezhnaya, and occasionally Novolazarevskaya (broadcast at 0930 or later), plus Halley and (irregularly) for Punta Arenas for 1200 (broadcast at 1530);
7) forecasts: at 1530 and 2130, maritime forecasts for northern and southern Drake, Bellingshausen and Weddell seas (Antarctic Peninsula sub-area no longer done) in plain language and MARFOR code; Diego Ramirez–Frei air route forecast in ROFOR code; Frei surface analysis for 0000, 1200 and 1800; and New Zealand surface analyses;
8) Soviet satellite neph-analyses (vortices, frontal bands, cloud lines, etc.), delayed nearly 24 hours.

The 5302.5 kHz frequency is practically the only usable one; 11662 is rarely heard, and 15470 is unheard. Emission power is stated as 5 kW, but often signal strength drops sharply as the ship gets beyond an 80 km radius and reception becomes badly garbled. Fax broadcasts of surface charts for 1200 and 1800 are made after the 1530 and 2130 teletype broadcasts respectively.

The shortcomings of the Frei radioteletype broadcast make the point-to-point voice (SSB) circuit for exchange of surface reports between Frei and Marambio (usually on 4490 kHz) especially important for collection of data in the Peninsula and adjacent areas. Another often-used frequency is 8980; alternates are 11440 and 3420. First, Marambio collects its data from the Argentine stations plus Arctowski and Juan Carlos I. Meanwhile the Frei operator is listening-in, and asks Marambio for repeats if he has been unable to copy. Marambio then sends his own report, and Frei passes to him the Chilean observations, plus reports from Artigas and Great Wall.

Most stations, including Polish Arctowski, read their five-digit groups in Spanish, with digits grouped two-one-two: thus 89056 becomes 'ochenta y nueve-cero-cincuenta y seis'. Errors sometimes creep in, for example '60' for '70' which sound alike in Spanish. Frei and Marambio read fast, making the messages difficult to write.

Listening on 4490, and preferably, simultaneously on 8980, should be started at H-35, ie thirty-five minutes before the nominal three-hourly synoptic hour. In the 1989–90 season, Juan Carlos I was usually the first to report, followed by Jubany and Arctowski (whose heavy accent and strong signal makes it easily recognized). Frei's own observation is usually the last one to be read, at about H-10. Great Wall and Arctowski send their WX only at the six-hourly schedules, that is 0000, 0600, 1200 and 1800; Great Wall's SYNOPs are passed to Frei by VHF, exceptionally on 3100 kHz.

The Chilean bases Prat and O'Higgins, and Artigas reports, and occasionally Chilean SHIP reports from *Piloto Pardo*, *Capitan Alcazar* and *Yelcho*, are collected on 3100 kHz, beginning at H-65, more than an hour before the synoptic nominal time. After sending his collection to Marambio, Frei comes on 3100 and transmits his own observation to Prat and O'Higgins, about H-10.

It is thus possible to check data by listening to several sources. For example, a report from Prat (Greenwich Island) can be received direct as sent to Frei on 3100, one hour before nominal hour (SSB), then heard in relay from Frei to Marambio on 4490, 15 to 10 minutes before nominal hour (SSB), and if necessary checked in the collective from Frei 30 minutes after nominal hour (RTTY). Similarly a report from Arctowski (Admiralty Bay, King George Island) can be heard direct on 4490, about 25 minutes before nominal hour (SSB), in relay by Bellinghausen to Molodezhnaya, between about 5 minutes before to 10 minutes after the nominal hour, on 13385 (CW), again in collective with the Argentine group from Frei 30 minutes after the synoptic hour (RTTY), and finally after a three-hour delay with Soviet reports in Frei's broadcast (RTTY).

British collections

UK reports are collected by Faraday on a number of frequencies, quick shifts of channel often being made to contact different bases and ships. Collection usually starts about 25 minutes before the nominal synoptic hour, Palmer being the first on 4067 kHz, followed by Signy, Rothera, Fossil Bluff, Halley, and ships RRS *John Biscoe* (ZDLB) and RRS *Bransfield* (ZDLG), on 9106, 11055, and 5800 kHz. An alternative is 14915, where contacts have been heard with RS *Polarstern*. Palmer may use VHF to send his weather to Faraday. Curiously, British operators chatter first, then send the numbers: Chileans and Argentines do the opposite.

Unfortunately the Faraday-Frei link could not be found; it is probably made by HF RTTY every 6 hours, and according to information seen posted at Frei receiving station, frequency used is 5080 kHz.

The Soviet CW system

Because of the use of radiotelegraphy (Morse), which often pulls through interference and poor ionospheric conditions when other modes fail, together with the wide distribution of land and ship reports and efficient operating practices, Soviet point-to-point communications have become a particularly useful source of meteorological data for the Antarctic and indeed for all of the southern hemisphere oceans. Within about 40 minutes around synoptic hours, it is possible on just two frequencies — 13385 and 12604 kHz — to collect surface reports for the whole Antarctic continent and from ships all around the southern oceans, in the Atlantic, Pacific and Indian sectors. Figure 2 shows approximate positions and tracks of some Soviet ships copied in the 1989–90 season. Indeed, in the absence of Grytviken and Stanley information, Russian ships have become practically the only source of synoptic reports for the southwestern Atlantic. Soviet fishing fleets are ever present around South Georgia and the South Orkneys, providing surface data in summer. Other Soviet ships are often off the coast of Argentina, between 40° and 50°S. Table 4 lists Soviet ships from which WX was copied during the 1989–90 season, for the three areas mentioned.

Ships in transit do not assure coverage of a target area, but the author has twice been lucky enough to get Russian ship reports near Cape Horn, of all places, when in dire need of data for the Drake Passage area. One ship (UWRY) was copied not on the regular WX contact with Bellingshausen but on an odd frequency, 16713 kHz, where it worked URL and sent weather addressed to Kiev. An unusual track, and a source of surface data for seldom travelled waters, was followed by URJP, a fishing vessel bound for the Ross Sea, coming down the southwestern Atlantic and entering the Pacific sector through Drake Passage (Fig. 2). In 64°S 88°W on 9 February 1990 it reported a 30 kt wind from WNW and 986 hPa pressure. This information was useful in defining the position and strength of the Bellingshausen Sea low pressure system, often a source of storms that, despite satellite data, hit unannounced the Antarctic Peninsula area from the west. Wind speed in USSR ship reports is given in ms^{-1} second, and only research vessels include the dew point group in the message. Some pressure readings may be unreliable.

The 12604 frequency is used by Soviet ships to contact UGE2 Bellingshausen and send reports mainly for 0000, 1200 and 1800 hours; the 0600 observation may be sent together with the 1200 report. Contacts begin at 20 to ten minutes before the nominal hour, and last until 15 minutes past the hour. Alternate frequencies are 8401 and 16709. UGE2 answers on 12843, a frequency also used by RUZU. In other sectors of the Antarctic, Soviet ships report on 8377 and 12571.5 kHz. One ship may collect and relay information from others of a fleet. In past seasons it was found advantageous to listen directly on the Soviet fleet's collection frequencies, such as 6305. Sometimes coded synoptic reports from 15 different ships could be copied on this frequency, at a mean rate of one report per minute. Soviet 'radists' are indeed crack CW operators.

Soviet ships also use the 13385 point-to-point CW frequency to send WX to RUZU Molodezhnaya and other Soviet stations. Some of the main relief and research vessels that have been identified are UMFW *Prof. Zubov* and URWW *Mikhail Somov*. UMFW uses mainly RTTY rather than CW and sends radiosonde observations; it has been heard on RTTY on 16705 kHz.

The 13385 CW frequency is the main channel for intercommunication among Soviet Antarctic stations. Only surface weather (every three hours), daily weather summaries and short general messages are sent on this frequency. Radiosonde and ship reports and all other traffic go by RTTY on different frequencies beginning about 20 minutes after the synoptic hours. Bellingshausen UGE2, for example, uses 13865 for this traffic (RUZU answers on 13505). RTTY frequencies may also be used for voice contacts. Numerous such frequencies have been announced by operators: UGE2-RUZU on 14645, 14985, 17535, 10555, 10100; UDR3 Russkaya on 13905, 10140, 14747; UDY Novolazarevskaya on 7665, 13505; RULE Druzhnaya-1 on 8105, 13505; ULO75 on 10100, 8105, 7485; ULO77 Druzhnaya-2 on 12252; UPY on 7435 kHz. On 13385 CW, UGE2 sends Bellingshausen's and Arctowski's surface reports to RUZU at H+05; UDY Novolazarevskaya relays SANAE's WX; and DB9020 regularly works RUZU and sends Georg von Neumayer's reports. The German radio-operator, Susanne, was affectionately treated by her Soviet colleagues.

Southern cone of silence

Knowledge of weather situation along approach paths of southern Pacific Ocean depressions is of great interest to forecasting for the Drake Passage and Antarctic Peninsula areas. Some cyclonic storms may suddenly swerve southwards after reaching southwestern Chile and hit the tip of Antarctic Peninsula. Yet the 'cono sur' or southern part of South America and adjacent seas have become a zone of silence for radio weather broadcasts.

Beginning November 1988, Chile suppressed its three-hourly CW broadcast of surface observations taken at strategically-located posts along the storm's approach route, such as Evangelistas, Horn and Diego Ramirez islands. This broadcast was formerly made by the Chilean Navy station CCM, replaced later by CBM, the coastal station, both located at Punta Arenas. The explanation personally given to a Brazilian Navy officer and the author during a visit we made in December 1988 to the Magallanes Radio Maritime Centre (station CBM), was that 'ships were no longer using the transmission, because they have fax and satellite data'. In the 1988–89 season we tried the Chilean's offer to get the Magallanes collective by contacting CBM on point-to-point CW maritime

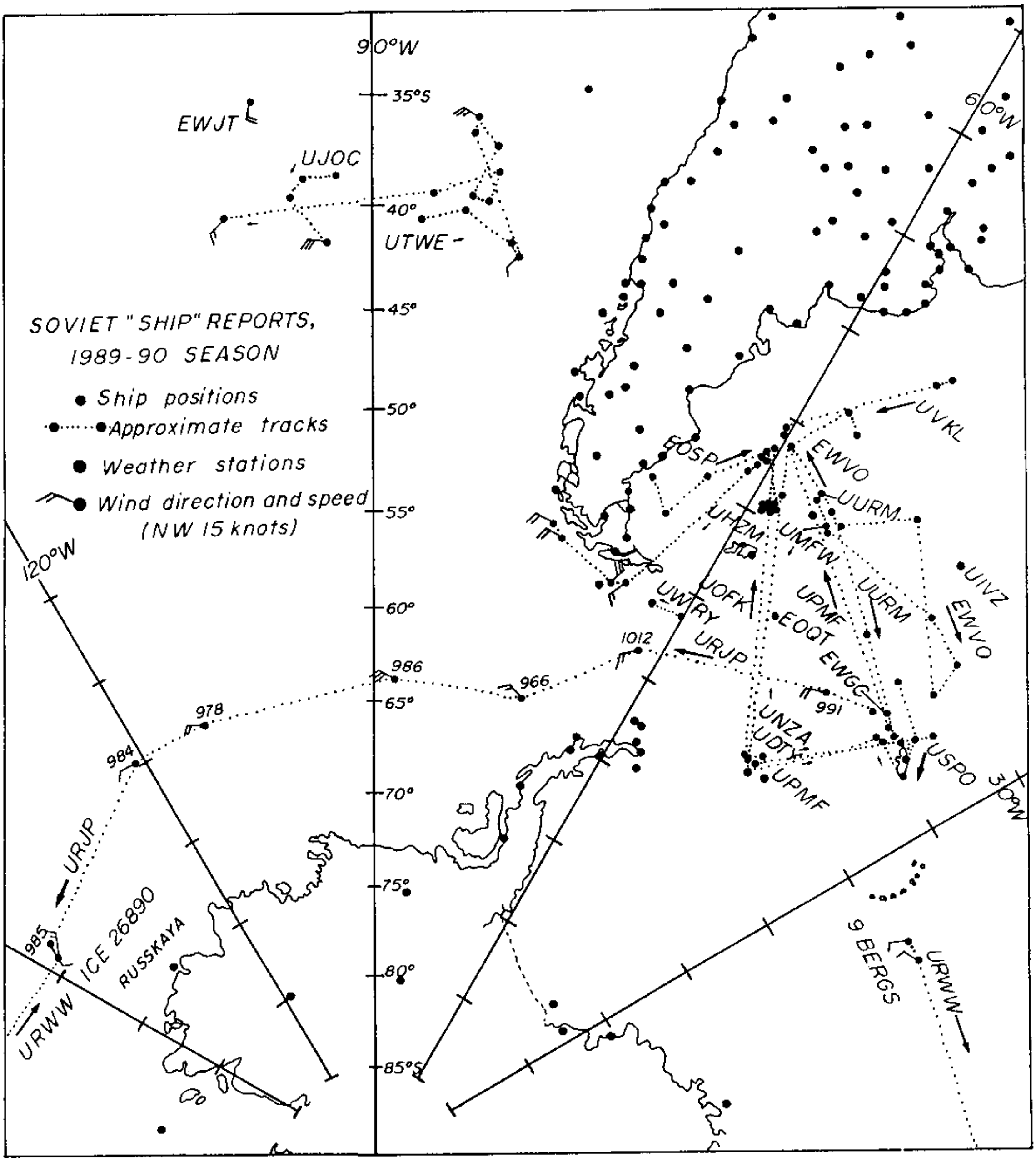

Fig. 2. Soviet ship reports.

mobile bands, but long delays made this unsatisfactory.

Three alternative sources to the Magallanes three-hourly broadcasts, all on RTTY, were (1) CAK Santiago, a point-to-point aeronautical station formerly using 11100 and 14600 kHz, which went out of service as the Chilean national microwave link replaced HF radio (this station was also a source of Argentine and Antarctic reports); (2) CCM, the naval station at Punta Arenas, currently heard on 4360, 6475 and 8220 kHz, but using high-speed transmission which could not be copied by our equipment; and (3) Frei Antarctic b/c itself, which used to transcribe the CCM or CBM transmission, but no longer does so. Southern Chile reports may be available at Frei through some other link; data transmission on 16430 kHz is a possibility.

Difficulties in this quadrant are compounded by the absence of radio reports from Argentina, the Falklands and South Georgia. The LRO/LRB Buenos Aires RTTY broadcast, once monitored by Antarctic bases such as Arctowski and Bellingshausen, ended in May 1985: Stanley's silence dates much further back. The once-famed 'FICOL' (Falkland Islands Collective) ceased a long time before the 1982 conflict, and since then no radio reports are available for the Falklands, South Georgia, or HMS *Endurance*.

Consequently, when a forecast for a Drake crossing decision becomes critical, such as in recent cases of crippled ships like the US icebreaker *West Wind* or the Peruvian oceanographic vessel *Humboldt*, tension rises over the air waves. Even *Barão de Teffé* has been asked for weather advice, despite the existence of better-equipped forecasting centres in the area. This is probably because fax charts and routine forecasts transmitted twice a day are deemed insufficient, and indeed can never replace up-to-date raw data for following up the evolution of quickly-changing weather patterns. The most recent pressure-tendency field, for example, is most important and not available from official bulletins. Thus the collection of data to support a Drake crossing decision has put the author's radio listening and meteorological skills to the test, where every scrap of information on weather counts. In one instance our only clue was a message from M/V *Mungo* informing that departure from Ushuaia had been delayed 'due strong wind and pilot refuse sail'.

Other ships and fishing fleets

Ships of opportunity, besides the Soviet and other Antarctic ships already mentioned, may yield additional or alternative sources of weather information on maritime mobile bands. Chilean merchant ships, when working CBV Valparaiso or CBM Punta Arenas, send messages to the meteorological service 'Servimet' containing weather information in plain language, arranged in a special form (items separated by letters A, B, C, etc. in alphabetical order). Frequencies heard in CW are 12597, 12610, 12614, on the 12 mHz ship band; 8382, 8386, 8388 and 8393, in the 8 mHz band; and 4181.8, 4199 and 3201, in the 4 mHz band. Schedules are twice daily around 1015, 1115, 1215 and 0015. Chilean ships report position at 1100 and 2200, and may also use 4143.6 and 5385 kHz voice.

A most interesting source is CBAB *Akebonu Maru 75*, a fishing factory boat which frequents 'zona de pesca antartica', including King George and Elephant islands waters. It works mainly on 12597 at 1015, 1115 or 1215, and on 4199 at 0015. On reaching the fishing grounds it stops sending weather and operational reports in plain language, changing to coded messages of ten-digit groups. However, its position may be given out by CBM broadcasts of shipping movements at 0200 and 1400. A Chilean ship heard in northern Drake Passage is CBUN *Unzen*. Chilean naval vessels such as CCPP *Piloto Pardo* and CCYO *Yelcho* operate RTTY or CW on 4129 or 4150 kHz, and voice on 3100, 5100 or 6200 kHz. CB2832 *Capitan Alcazar*, operated by the Chilean Antarctic Institute, was heard in CW on 12598 on 5 February 1990.

Japanese-speaking ships were heard on 8432 kHz keeping almost hour-long regular schedules at 1200, 1600 and 2200. On 3 February 1990 Polish-speaking ships appeared on this frequency and then mutual contacts were established in English. *Las Palmas*, the Spanish Antarctic expedition ship, uses 4601.6 and 4060 kHz voice.

Air-to-ground communications

Aeronautical radio circuits in southern South America, also covering civilian and military flights to Antarctica and part of the trans-polar route flown by Aerolineas Argentinas to New Zealand, are eventual sources of weather information, including METAR surface observations, and of upper air winds and temperatures which are reported with the aircraft position messages. An important frequency is 10024 kHz, a Chilean channel including Punta Arenas, Puerto Williams and Marsh. This frequency is used by Chilean and Brazilian Air Force planes flying from SCCI (Carlos Ibanez airport at Punta Arenas) to SCRM (Rodolfo Marsh airfield on King George Island); alternates are 5583, 6610, 8906, and 13300.

During Chilean Air Force flights to Marsh a special circuit is activated on 13241. Brazilian Air Force C-130s use 17957 and 13325 to talk directly with *Barão de Teffé*. Weekly transpolar flights are identified as 'Argentina 881' (outward) and '880' (return). On 31 January 1990 flight 881 was heard beginning at 1354 on 10024 reporting a medical emergency aboard and requesting a doctor with blood calcium analyser at Rio Gallegos airport. Reporting successive positions 56°S 99°W and 55°18'S 85°31'W, it crossed the area where a low pressure system that would later affect *Teffé*'s crossing of the Drake was developing.

Argentine small aircraft flying in the Antarctic Peninsula area use regular voice frequencies employed by the bases and refuges, such as 4490 and 4705 kHz, usually identifying as 'Aguila'. Argentine Air Force C-130s on 11282 and 13255 work Marambio, Rio Gallegos and Comodoro Rivadavia; 11282 is used by commercial planes including trans-polar flights. A special frequency of 11237 has been used by Marambio to collect weather data when a flight from the main continent was on. On 19 January 1984, USSR aircraft 41808 (possibly an IL-14 flying near Druzhnaya) was heard on 5510 contacting EXYH in CW; also announced 6210 kHz.

Free enterprisers

Hearing the Adventure Network International radio communications from Punta Arenas, Patriot Hills camp near the Ellsworth Mountains, and several aircraft, gave me the feeling that Antarctic history is again being made through private enterprise. ANI has shown that Antarctica's interior can be reached safely and routinely by large aircraft equipped with conventional wheeled landing gear (Swithinbank 1988, 1989), opening the continent to climbers, ski trekkers, and scientists (Morrow 1986; Hodgson 1990). Frequencies were mainly 15026 and 11228 kHz, and the most regular time schedules were 1100 and 2300 hours. Alternatives were 14986 (shared with the International Transantarctica Expedition), 15060, 11220, 11123 and 16000 kHz. Aircraft and field parties also used 5810, 5020 and 8957, and aircraft were heard on the southern South America and Antarctic Peninsula area's aeronautical frequencies 10024 (contacting Marsh and Punta Arenas) and 7775 (working Rothera). During flights, Marsh may use 15026 and the other company's frequencies as well.

Traffic of all sorts was heard on these frequencies, the pilots providing many useful insights into weather conditions. In a particularly interesting flight of 27 January the DC-6 took off from Punta Arenas at 1745 and landed at Patriot Hills at 0237 of the 28th. Reporting position 69°15'S at 2300, at 10,000 ft altitude, the pilot commented that this was his most spectacular flight so far, the sky being completely clear. In fact, thanks mainly to the synoptic observation from Fossil Bluff, on Alexander I Island, I could locate a large high pressure cell displaced towards an unusually southwesterly location, as if spilling over from the Weddell Sea side of the Antarctic Peninsula. In consequence, at Fossil Bluff, without the usual local katabatic wind, the temperature was rather low (-5.6°C). On the other hand, weather at Patriot Hills was deteriorating, with wind from 220° gusting to 40 kt and horizon obscured by clouds. A turn-around decision threatened, but within an hour weather improved, with good horizon and moderate contrast. The DC-6 reported 'pretty good head winds'; since upper level winds at Vostok (according to Frei broadcasts) were southerly, 31 to 37 kt, winds must have been turning anticyclonically (to the left) over the polar plateau.

Also interesting, and providing moments of real suspense, on Adventure Network's radio frequencies, were communications of two private sledging expeditions traversing Antarctica, the International Transantarctica Expedition (ITE) and the Reinhold Messner expedition. Both were supported by ANI flights. ITE, led by J.L. Etienne and W. Steger, kept regular contact with Antarctic stations and with the outside world, including support yacht *UAP*, but Messner used no radio except an ARGOS satellite transmitter for position information only.

Yachts and radio amateurs

Amateur radio stations located on or close to Antarctica, yachts, and radiotelephone stations carrying personal traffic can be a source of general and of weather information. Amateur operator LU6XPA (Raul Bauducco) in Ushuaia (Tierra del Fuego), who provides weather and other radio support services to yachts, is equipped with several antennas and computerized gear which allow him to operate voice, CW, RTTY, TOR, and packet modes. Amyr Klink, a Brazilian wintering-over solo at Dorian Bay (Wiencke Island) in *Paratii*, an aluminium-hulled sailboat, operated station PY2KAQ/MM on the amateur bands. Late in January 1990 he lent a transceiver and antenna to the Argentine Navy hydrographic ship *Gurruchaga* (call sign A-3) which had lost radio contact with the icebreaker *Almirante Irizar*, then in the Weddell Sea, causing considerable worry to the Argentine command. Argentine ships involved were heard on 8980 and 4490, and Klink on 21190 and 14190 kHz. Buenos Aires LTS9 has been heard on 20132 kHz contacting LTA8 Belgrano, LTS2 San Martin, and Q-5 *Almirante Irizar*, between 1400 and 2200, for private RT conversations. According to an intercepted message, DNA's (Antarctic National Department of Argentina) SSB frequency 18113.5 has been replaced by 18667.5, and 9393 should be corrected to 9333 kHz.

Some applications to forecasting

The following examples show how meteorological data collected by radio monitoring were applied to operational weather forecasting in ships of the Brazilian Antarctic Programme. My experience in developing techniques for surface weather forecasting and 'nowcasting' for operational purposes, lays less emphasis on such final products as fax charts and numerical prognoses, and more on immediate individual reports, combined with greater awareness of local influences. In conclusion, I draw attention to the deterioration in availability of meteorological data following the introduction of satellite communication links, which is adversely affecting weather forecasting in the South American sector of the Antarctic.

For comments on practical or operational weather analysis in this quadrant see Robin (1949), Pepper (1954), Mansfield and Glassey (1957), Boudgouste (1958), Guozden (1959), Schwerdtfeger and others (1959), Schwerdtfeger (1962, 1979, 1984), Villela (1986, 1987), Villela and Festa (1986), Salter and Merrick (1989).

High winds drag ship aground

At 7 o'clock local time (1000 UTC) on 10 March 1987, RV *Prof. W. Besnard*, while taking water aboard, ran aground close to Comandante Ferraz station, at Martel Inlet, Admiralty Bay. Hit by sudden 60-kt gusts of wind from NE, the ship dragged both anchor and tying buoy and was driven to 22 m from the shore line. The ship's captain needed an immediate forecast, especially of wind, on which prospects for saving the ship depended. The storm was expected, but slow in coming. Previous signs of the depression's swerving trajectory were contradictory: characteristic hook-shaped *cirrus uncinus* ice clouds had appeared the previous afternoon, but pressure kept steady at 1010 mbar. The barograph trace indicated that the fastest pressure drop preceded the strong winds by four hours. I quickly plotted and analyzed a 1200 UTC chart after copying reports directly by radio, beginning at 1105 UTC with the Chilean reports on 3100 kHz. Later completed with data from Frei's broadcast,this showed clearly that the low center was far off to the south and, judging from its course, winds would veer to the NW and W: if they backed and became easterly, the ship could be thrown over submerged rocks close by. Winds shifted as forecast and high tide released the ship six hours later with minimal damage.

A rapidly-developing Drake low

Early in the morning of 1 February 1990, north-bound aboard *Barão de Teffé* some 140 km SE of Cape Horn, fax charts showed nothing unusual, except for a weak and open frontal wave off Chile's southwestern coast. But at 1200 UTC a rapidly-falling barometer and backing wind (NW shifting to N, about 20–25 kt) indicated a probable depression approaching from W or NW. In the absence of Chilean synoptic data (we were in the southern cone of silence) I attempted to copy weather reports direct from Chilean lighthouses on the point-to-point voice frequency at 5385 kHz, as sent at 1300 to Magallanes Radio.

A report from Espiritu Santo on Magellan Strait, and our own ship's observation, were enough to close a couple of isobars around a small, quickly developing low to WSW

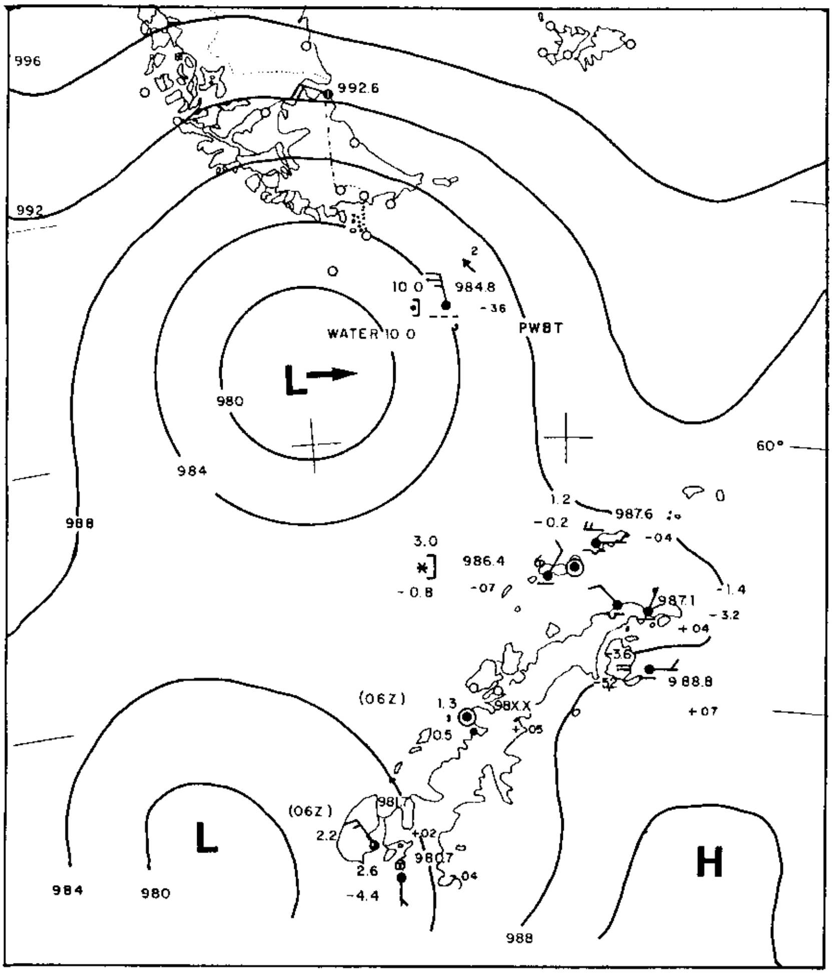

Fig. 3. Rough chart, 1 February 1990: an intensifying depression is approaching from the west.

of the ship (Fig.3). Within a few minutes the wind veered from N to NW and the speed gusted to 60 kt. Six hours later a tall wave hit the pilot house and toppled over the flying bridge, 13 m high. The wind had veered W and kept there, as the depression passed to the south of the ship, sparing us from the harder SW gales usually found behind Drake lows. The single Chilean report helped to establish the depression's trajectory and allow a correct forecast. Such rough charts, sometimes based on incomplete and garbled data, but constructed on the very latest reports, are useful for a quick operational evaluation. Smaller auxiliary charts were frequently used for this purpose.

Persistent Antarctic Peninsula highs

Extensive semi-stationary anticyclonic conditions over the Antarctic Peninsula are sometimes associated with prolonged spells of fair weather. These highs develop first over the frozen Weddell Sea, then expand: the surface anticyclone may be associated with an upper ridge extending from lower latitudes. Figure 4 shows an exceptionally persistent high which lasted from 27 January to 7 February 1984 and gradually extended north-westwards across Drake Passage. Accurate analysis of its northern extension was made possible by full use of all reports for southernmost Chile, then available through Magallanes radio broadcasts. Position and strength (above 1013 hPa) of the centre are plotted according to an Argentine Navy weather bulletin formerly available through the LOR radioteletype broadcast. Observations from Belgrano (034) and South Pole (009) have been added at the lower margin of the chart.

Similar though shorter-lived situations occurred in late January 1989 and 1990. In the latter, a subsidence temperature inversion of 8° was observed by a helicopter as it climbed from 4000 ft (-10°C) to 6000 ft (-2°C) over Elephant Island. This same high provided clear skies for ANI's DC-6 flight to Patriot Hills (see above), and had around its northern periphery a well marked inertial jet 'front' (see below) located between Prat (Greenwich Island) and Juan Carlos I (Livingston Island) on the 1200 UTC chart.

Cold low-level inertial jet stream

Wind and weather patterns in the South Shetland Islands and Bransfield Strait are fairly frequently controlled by this phenomenon, first described by Parish and Schwerdtfeger in 1977 (see also Parish 1977, 1983; Schwerdtfeger 1979, 1984; and Villela 1986, 1987) and characterized by steady E winds, of 15 to 30 kt (more if combined with pressure gradient winds), strongly curving anticyclonically (from right to left) due to Coriolis force. Wind direction becomes successively SE, E and NE, after the cold air leaving the Weddell Sea has turned around the tip of Antarctic Peninsula and moved westwards.

Since the jet's source is on the eastern side of the Peninsula, where it is generated by mountain-induced baroclinicity, reports from stations such as Marambio, Matienzo and Esperanza become all-important for forecasting it. In inertial jet situations these stations typically report 30 to 40 kt winds from SSW and relatively cold temperatures, around -5° to -10°C in summer. High pressure on the Weddell Sea coast at stations such as Belgrano and Halley also favour the jet's occurrence. Some of the consequences of the inertial jet effect of interest to the weather analyst will be mentioned. On surface charts, it may distort flow patterns around depressions moving through southern Drake Passage, such that winds continue from E or SE rather than from S or SW as the pressure gradients would require, long after the low centre has moved away to the east. The jet is often associated with the lowest temperatures observed at the South Shetland stations.

Also important, convergence of the inertial jet against opposing synoptic-scale flow may produce abundant

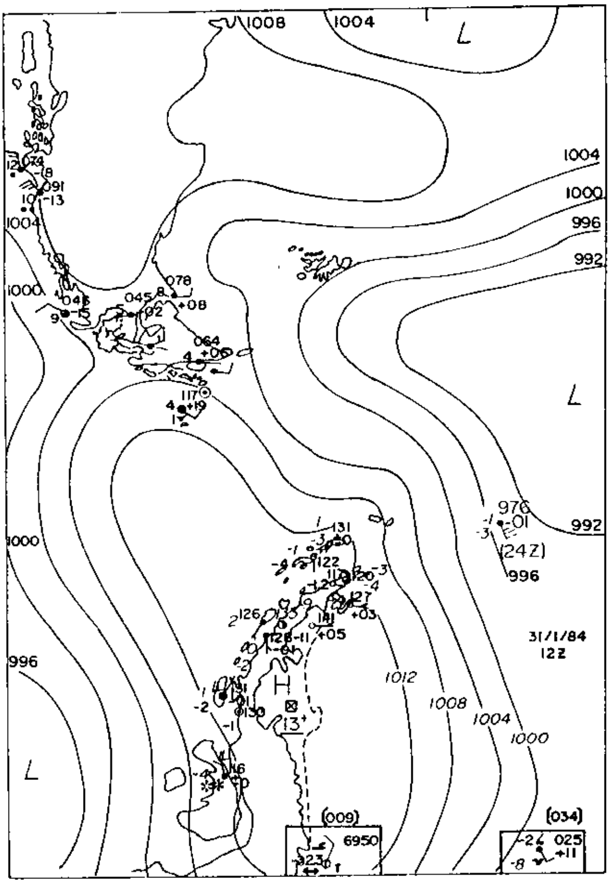

Fig. 4. Persistent high pressure cell over Drake Passage and Antarctic Peninsula, 1200 UTC 31 January 1984.

snowfall, as the warmer maritime air from the west and north overruns the colder and drier air to the east and south. Such is the case for 24 February 1984, shown in Figure 4, where a 25 kt wind observed by *Prof. W. Besnard* opposes a 12-kt SW wind reported by Prat station, 10 miles to the east (Villela 1987). Actually, the situation shown reflects an approximate one-hour difference in 'synoptic' observation time, since Chilean stations make their observations about 70 minutes before the nominal hour, as can be noticed by the time they transmit their messages by radio (see above), whereas we did ours on board *Besnard* about 15 minutes before the hour. Three hours later, both Prat and *Besnard* (which had moved slightly to WSW) reported E winds, and Prat's temperature dropped 1.6°C. Snowfall decreased as the inertial jet 'front' moved away to the west. The time difference in 'synoptic' observations made by Antarctic stations run by different countries may be a source of error in chart analysis and lead to misinterpretation of weather evolution, particularly when pressure tendencies are strong.

Wind shadow effect

Among the many local effects on Antarctic weather, the wind shadow or leeward effect appears to be universal, particularly in the South Shetland and South Orkney islands. Whereas stations on King George Island, for instance, directly exposed to maritime winds may report fog, precipitation, or heavy cloudiness, sheltered sites may exhibit considerably better conditions. One example of many available may be cited, received at 1200 UTC on 9 Februrary 1990. Under a NW airflow, bringing in relatively warm and moist air from Drake Passage, Bellingshausen was closed in by fog and 200 m visibility, whereas Arctowski reported visibility above 10 km, broken clouds, and lower relative humidity. A slightly higher temperature at Arctowski probably reflected katabatic warming due to the 600 m high mountain range to NW of the station. Winds of 8 kt were from 300° at Arctowski and 330° at Bellingshausen.

Considering these differences, the 'surfeit' of routine weather observations from King George Island's many stations, commented on by several writers (for example Headland and Keage 1985), in fact welcomed by forecasters. We have grown used to using all of the five or six regularly-available reports, since they contributed to a better feel of local conditions and greater confidence in synoptic analysis.

Conclusion

In my work of shipboard weather analysis and forecasting for operational purposes in the Brazilian Antarctic Programme, I found it advantageous to receive weather reports by radio directly from the original sources by monitoring point-to-point communications, rather than depending on the regular collective broadcasts. This saved time, which was often crucial to operational decisions, and gave more complete data coverage and greater flexibility in operating schedules.

I hope that this information on radio weather transmissions will be useful to meteorologists and radio-operators working in the Antarctic, especially in the American quadrant. Amateur radio-operators and short-wave listeners may also find in Antarctic communications a fertile field for their hobby, and this report may enable them to follow first-hand the thrilling and historic developments in exploration and research in the last geographical frontier of the planet (Villela 1948).

The Antarctic radio communications system, providing for frequent exchange of weather information, and the informality characterizing working procedures among operators from different countries, vividly reflect the spirit of close international cooperation prevailing in the Antarctic Treaty area. To the professional meteorologist, our field experience in combined radio monitoring/weather analysis work raises some questions concerning the adequacy of operational forecasting methods currently adopted. The modern forecaster working in the big central meteorological offices is assisted by computers and mathematical models, but we find ourselves working differently in the Antarctic, perhaps more like old-fashioned meteorologists. We use local feel and first-hand experience, attention to individual reports and thorough knowledge of each station's physical surroundings, and we unceasingly follow local and general weather evolution.

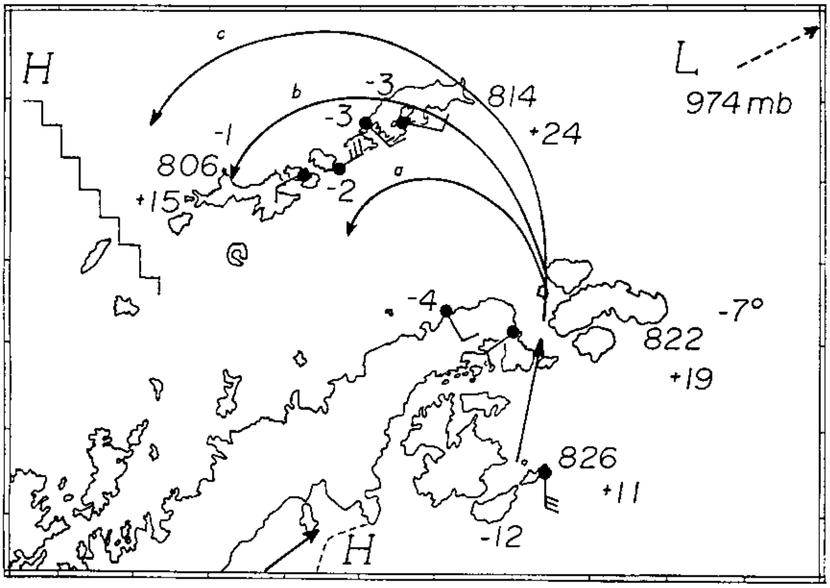

Fig. 5. Inertial jet wind 'front' near Greenwich Island, causing moderate snow fall. Hypothetical tracks (Parrish and Schwerdtfeger 1977) added for a 20 ms-1 initial velocity and three surface drag conditions, (a) over water, (b) over ice, and (c) zero drag.

Numerical products are undoubtedly valuable to anticipate changes in large-scale atmospheric patterns, even in the south polar zone, but translating prognostic charts to a local weather forecast of surface conditions in the Antarctic needs special skills and experience (for a recent example of sophisticated forecasting of clouds, temperatures and winds aloft for high-altitude flights over Antarctica see Salter and Merrick 1989). Strong interaction between land, water, ice and atmosphere, and topographically-induced influences in Antarctica are such that concepts of dynamic meteorology may not apply in practice. In Antarctic field conditions, no mathematical technique can replace actual raw synoptic observations, for example in reporting a quickly-changing pressure field. To the operational forecaster, a gazetteer with hints on local weather peculiarities for each Antarctic station, such as contained in Pepper (1954), would be of much interest.

This issue of field forecasting style is also connected with the problems created by the introduction of new meteorological telecommunications systems. In my experience exclusive dependence on advanced technology such as satellite systems does not work well in practice for undeveloped regions like the Antarctic. Advanced technology is costly and needs more maintenance. Antarctic data are perpetually at loss in the meteorological Global Telecommunications System (GTS) today (SCAR 1985). Among results of 'modernization', there has been a progressive deterioration of weather data availability both in the Antarctic and in South America in the past five years. Radioteletype and radiotelegraph meteorological transmissions from Brazil, Argentina and Chile that used to be copied at stations in the peninsula area have all ceased; invaluable information is often missing or simply not available through the new means. Specially serious in adversely affecting Antarctic work are the loss of southern Chile broadcasts and the Falkland Islands collective. If Punta Arenas, Buenos Aires, and Stanley restored their radio broadcasts, they would be welcomed by all parties working in the American quadrant of Antarctica.

Acknowledgements

I gratefully mention the following who helped me realize a Brazilian boy's dream of going to Antarctica: the late Rear-Adml George J. Dufek USN; the late Hugh Odishaw and Paul A. Siple of the US National Committee for IGY; Norman F. Kriebel of FBIS, Washington DC; and the late B. B. Roberts of Scott Polar Research Institute. I thank also the University of São Paulo and the Brazilian Navy, and I am particularly indebted to Sr Assis Moacir Duch, blind radio-operator of the Policia Civil do Estado de São Paulo, for expert technical assistance in installing radioteletype equipment on board RV *Prof. W. Besnard*.

References

Admiralty. 1987. *Admiralty list of radio signals, Vol.3, Radio weather services.* Taunton, Somerset, Hydrographer of the Navy.

Armada Argentina. 1988. *Radioayudas a la navegacion.* 7th edition. Buenos Aires, Servicio de Hidrografia Naval (Publicacion H.221).

Boudgouste, J. L. 1958. Aspectos del pronostico del tiempo en la Antartida. *Boletin del Centro Naval* 75(638): 557–97 (Contribucion del Instituto Antartico Argentino 15).

Guozden, H. 1959. *La campana antartica 1956–57.* Contribucion del Instituto Antartico Argentino 19.

Headland, R. K. and Keage, P. L. 1985. Activities on King George Island group, South Shetland Islands, Antarctica. *Polar Record* 22 (140): 475–84.

Hodgson, B. 1990. Antarctica: A land of isolation no more. *National Geographic Magazine* 177(4): 2–51.

Mansfield, A. W. and S. D. Glassey 1957. Notes on weather analysis in the Falkland Islands Dependencies, Antarctica. *Falkland Islands Dependencies Survey Scientific Reports* 16.

Morrow, P. 1986. *Beyond Everest.* Camden East, Camden House.

NOAA 1985. *Selected worldwide marine weather broadcasts.* Silver Spring, Maryland, US Department of Commerce - National Oceanic and Atmospheric Administration.

Parish, T. R. 1977. *A low level jet of cold air near the tip of the Antarctic Peninsula: an example of inertial winds.* MS thesis, Department of Meteorology, University of Wisconsin, Madison, Wisconsin, USA.

Parish, T. R. 1983. The influence of the Antarctic Peninsula on the wind field over the western Weddell Sea. *Journal of Geophysical Research* 88(C4): 2684–92.

Parish, T. R. and W. Schwerdtfeger 1977. A cold, low-level jet stream in the Bransfield Strait: an example of inertial flow. *Antarctic Journal of the United States* 12(4) :171–72.

Pepper, J. 1954. *The meteorology of the Falkland Islands and Dependencies 1944–50.* London, Falkland Islands and Dependencies Meteorological Service.

Robin, G. de Q. 1949. Notes on weather analysis on the fringe of Antarctica. *Meteorological Magazine* 78(926): 216–56.

Salter, P. R. S. and Merrick, S. D. 1989. A note on forecasting for the Airborne Antarctic Ozone Experiment. *Meteorological Magazine* 118 (1400): 59–63.

SCAR 1985. Appendix 5: working group on logistics. Annex: Antarctic Telecommunications. In: SCAR Bulletin, No.80, May 1985. *Polar Record* 22 (140): 577–611.

SCARCOM 1985. *Antarctic telecommunications guidance manual (Vol.II, Operators handbook).* Canberra, Department of Science and Technology, Antarctic Division.

Schwerdtfeger, W., de la Canal, L. M. and Scholten, J. 1959. *Meteorologia Descriptiva del Sector Antartico Sudamericano.* Buenos Aires, Instituto Antartico Argentino (Publicacion 7).

Schwerdtfeger, W. 1962. *Meteorologia del area del Pasaje Drake.* Buenos Aires, Republica Argentina, Secretaria de Marina (Servicio de Hidrografia Naval Publicacion H.410).

Schwerdtfeger, W. 1979. Meteorological aspects of the drift of ice from the Weddell Sea toward the mid-latitude westerlies. *Journal of Geophysical Research* 84(C10): 6321–27.

Schwerdtfeger, W. 1984. *Weather and climate of the Antarctic.* Amsterdam, Elsevier.

Sheffield, A. H. (compiler) 1957. *Antarctic radio communication manual* (revised edition). London, Pergamon.

Simoes, J. 1984. Brazilian Antarctic research programme. *Polar Record* 22(130): 325–26.

Swithinbank, C. 1988. Antarctic Airways: Antarctica's first commercial airline. *Polar Record* 24(151): 313–16.

Swithinbank, C. 1989. Non-government aircraft in the Antarctic 1988/89. *Polar Record* 25(154): 254.

Villela, R. J. 1948. SW transmissions from the Antarctic. *Short Wave News* 3 (9): 237–39; 3 (10): 264–66.

Villela, R. J. 1986. Results of synoptic analysis aboard R/V *Prof. W. Besnard* in the I and II Brazilian Antarctic Expeditions. *Anais da Academia brasileira de Ciencias (Suplemento)* 58: 187–204.

Villela, R. J. and Festa, M. 1986. Meteorological observations aboard R/V Prof. W. Besnard during the I and II Brazilian Antarctic Expeditions. *Anais da Academia brasileira de Ciencias (Suplemento)* 58: 205–18.

Villela, R. J. 1987. Some observations of the inertial cold jet north of the Antarctic Peninsula. *Anales, II Congreso Interamericano de Meteorologia - V Congreso Argentino de Meteorologia (Buenos Aires)*: 9.3.1–9.3.6.

Walton, D. W. H. (editor) 1987. *Antarctic science.* Cambridge, Cambridge University Press.

WMO. 1983. *The preparation and use of weather maps by mariners.* Geneva, World Meteorological Organization (WMO 595).

WMO. 1986. *Weather reporting (Vol.A: Observing stations; Vol.C: Transmissions).* Geneva, World Meteorological Organization.